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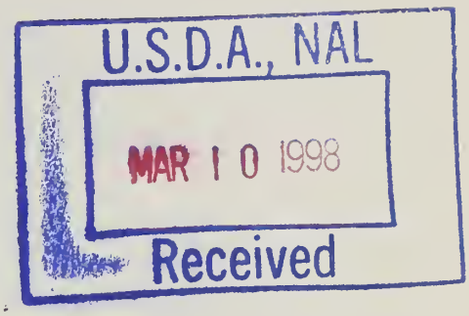
WATERSHED PROJECT EVALUATIONS IN SIX MILE CREEK, ARKANSAS

by Richard A. Blood



Natural Resource Economics Division
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in cooperation with

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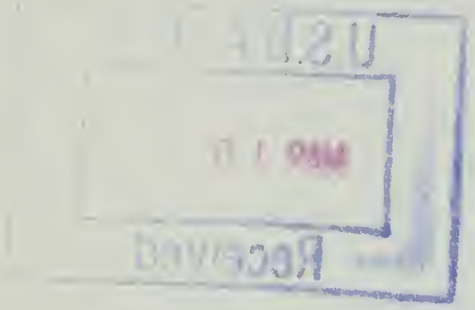
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CONTENTS

Summary

Six Mile Creek, a tributary of the Arkansas River, flows through Logan and Franklin Counties, Arkansas. A watershed protection and flood control project was authorized for Six Mile Creek in August 1954, as one of 65 similar projects throughout the United States. Federal funds for the project were made available by the Department of Agriculture Appropriation Act of 1954. The Soil Conservation Service, in cooperation with the Logan and Franklin County Soil Conservation Districts, completed the work plan in June 1954. Construction of the improvements, designed primarily to reduce flooding and to control erosion and sedimentation, began in June 1954 and was virtually completed by 1957.

The Department of Agriculture, assisted by the Geological Survey and Weather Bureau, observed and recorded changes occurring on Six Mile Creek Watershed from 1955 through 1966 in order to estimate the actual effects of the installed improvements. An interim progress report on this evaluation was published in July 1957. This final evaluation report summarizes through 1966 the watershed program effects that have been studied.

While the evaluation was carried on from 1955 through 1966, the period 1951-54 immediately preceding construction was used as a base from which to measure project-influenced changes. Rainfall and other hydrologic and sedimentation data were supplied by the U. S. Weather Bureau. Records obtained annually from farmer interviews were used for the land use, yield, and other analyses.

The Six Mile Creek project was planned to involve land treatment measures, 26 floodwater-retarding structures, 22.9 miles of stream channel improvement,

and 315 acres of tree planting on critical erosion areas. The estimated cost of the structural measures was about $1.305 million. Actually installed were 24 floodwater-retarding structures at an actual cost of $2.200 million, 29.4 miles of stream-channel improvement, 315 acres of tree plantings, and the planned land treatment measures. The increase in structure installation cost over the planning estimate was attributed to unanticipated rock excavation (40 percent), changes in design criteria (45 percent), and the general rise in construction costs (15 percent).

Average annual rainfall for the watershed area during the evaluation period was 42 inches, slightly less than the 70-year average of 45 inches.

The project provided flood protection for a cumulative total of about 132 thousand acres from 1957 through 1969, or 13.2 thousand acres annually. This was a reduction of 59 percent from the area which would have flooded under pre-project conditions. Based on comparative gaged runoff data for 1957 through 1966, these reductions in flooding should be moderately larger when based on a longer, more representative period.

Benefits from damage reduction to crops, pastures, and agricultural and nonagricultural property totaled $341 thousand or about $34.1 thousand annually. Annual benefits for crop and pasture were $27.1 thousand.

In addition to the reduction in flood damage, the project benefitted fishing and other recreational activities, municipal and industrial water reserves, stockwater-supplies, and irrigation. These benefits have been estimated at $4 thousand per year.

In response to the flood protection provided by the project, farmers in the watershed have intensified the use of flood plain lands. Although the

land use pattern in the flood plain varies from work-plan estimates, the average gross value of production exceeds the pre-project value by about $39.5 thousand annually. Most of the increase in production is attributable to increases in acreage and in yields of improved pasture. The acreage of improved pasture in the flood plain portion of the watershed increased about 44 percent during the evaluation period, compared with an increase of only 3 percent in the upland areas.

These data indicate a trend away from cash-crop farming to livestock farming in the Six Mile Creek Watershed. The change to livestock farming has caused a rapid decline in agricultural employment and an increase in off-farm employment. The rapid industrial development of the surrounding area has also contributed to the trend toward off-farm employment.

The pilot watershed project reduced flooding in downstream areas as planned, and benefitted the area in other ways, some of which were not foreseen during planning. The lessons learned from this project should aid future watershed planning.

This report is the final report on joint evaluation efforts of the Soil Conservation and Economic Research Services which began in the Six Mile Creek project area in 1955. A first interim progress report was published July 1957. While this final report is not intended for publication, its processing in this form for limited distribution will indicate the terminal findings of the studies. Additional data tabulations are omitted in the interest of brevity but will be maintained for a limited period in the files of the cooperating agencies.

WATERSHED PROJECT EVALUATIONS IN SIX MILE CREEK, ARKANSAS

by Richard A. Blood*

A pilot watershed program was authorized under the Department of Agriculture Appropriations Act of 1954 and was intended to demonstrate the effectiveness of upstream watershed protection in the control of tributary flooding. The enabling legislation provided for studies of the actual effects of the projects installed. Six Mile Creek Watershed was one of 8 pilot watersheds selected for intensive evaluation of the actual physical and economic effects. Such post-project evaluation of the installed improvements was expected to provide a documentary basis for testing and improving planning techniques, and to serve as a pattern for estimating probable results of future watershed protection projects. It was also expected to furnish additional information concerning some of the impacts of watershed protection measures. Finally, the evaluation of Six Mile Creek, along with the other watersheds being evaluated, was expected to provide a broad basis for appraisal and improvement of the watershed planning process.

Other agencies have assisted in the evaluations. The Weather Bureau summarized and printed rainfall data. Stream and reservoir gages were read and other hydrologic data were collected by the U.S. Geological Survey.

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Objectives of the Six Mile Creek Project

The major objective of the Six Mile Creek project was to significantly reduce flooding on the downstream flood plain, and so reduce damages from floodwater, erosion, and sediment.

The flood plain of this watershed has a history of frequent damaging floods. As a result, farm owners and operators had become reluctant to utilize this fertile land as intensively as they normally would in the absence of the risks involved.

The benefits from reduction of floodwater, sediment, and erosion damage were expected to occur primarily along the main stems of Six Mile and Hurricane Creeks. Benefits from more intensive use of land were expected to occur throughout the flood plain below the floodwater retarding structures. Conservation benefits were expected to occur throughout the watershed as a result of land use adjustments encouraged by the project.

Because this watershed project was a pilot operation, procedures for evaluating the effects of the project were included in the work plan. The stated objective of the evaluation was to determine the relationship between estimated and observed benefits of the applied watershed program.

The procedures for evaluation specified the hydrologic and sedimentation instrumentation needed to measure the effects of the program. Records needed to determine land use changes in the watershed following implementation of the program were also specified and appropriate cooperation was arranged with other Federal and State agencies.

The following instrumentation was specified for the hydrologic and sedimentation studies:

--Nine recording rain gages and 45 standard rain gages.

--Five water-stage recorders in stream and four water-stage recorders in reservoirs.

--Permanent range lines on Reservoirs No. 2, 5, 6, and 23 for sedimentation studies.

--Thirty-nine maximum-stage gages, located at selected valley sections throughout the watershed.

--A sediment sampling station and trap efficiency studies at Reservoir No. 6.

To measure the intensification of land use, annual records of land use were to be kept. Conservation benefits were to be assessed from records of land treatment measures installed, and from the changes in returns resulting therefrom.

Rainfall and stream-gage records were faithfully kept and published in Weather Bureau climatic bulletins and Geological Survey water supply papers, respectively. The base sediment survey and one resurvey have been made. Records of land use and crop yields on the flood plain, sample upland fields, sample drainage areas, and all reservoir areas were maintained as originally planned. A base economic survey of all farms in the watershed was made for 1954; one resurvey was made in 1959.

During interviews with farmers to obtain data on land use and yields, information was also obtained on land-treatment and conservation practices. Flooding and consequent damages to flood plain fields were also recorded.

It was initially planned to relate changes in land use to the capability class of the land, as defined by the Soil Conservation Service. It was

expected that with completion of the watershed protection measures, each unit of soil capability would be used nearer its maximum capability. However, summary by capability unit was abandoned early in the evaluation because there wasn't an adequate sample of the soil capability units represented in the flood plain to make an analysis possible. This inadequacy was aggravated by the decrease in use of the flood plain for crops. Some of the evaluation and analysis originally planned has not been possible because of the lack of physical information. This is particularly true regarding sediment accumulation in the 5 sample reservoirs.

The extension of the evaluation period has been less fruitful than had been anticipated. First, parts of studies begun earlier were dropped. Second, pre-project planning techniques were modified for reasons not related to the evaluation; the need for examining the techniques originally used in the Six Mile Creek Watershed was thereby nullified.

Another point to mention is that the watershed program has progressed very rapidly since the pilot watershed evaluations were initiated in 1954. In essence, the studies have lost much of their appeal because many of the project planning studies have already been completed. Extending the evaluation period may have made the results less timely, but it has also pointed out some shortcomings of the plan of study. For example, the need for selecting a control watershed without a project, or some other method of identifying project-influenced effects from nonproject-influenced effects, has become evident.

Procedures for Economic Evaluation

One method of evaluating a watershed development project is to choose similar areas for study--with one containing the project to be evaluated. If all other features of the areas are the same, the differences in performance can be attributed to the project. A variation of this approach is to compare changes within the project area with those occurring in the larger region surrounding the watershed. Pronounced differences in changes in the two areas may reasonably be attributed to the project.

A second method of evaluating a watershed project is by analyzing one or more time series for the project area. Although time series analyses are implicit in a study of similar areas, pure time series analyses would involve only a comparison of specific internal elements or ratios over time, without reference to factors in areas outside the study area.

A third evaluation approach is to determine the area of land that would be flooded with and without the project by applying the pre-project hydrologic procedures. Changes in land use intensity, cropping systems, and crop yields are recorded. The differences in the with-project and without-project effects are imputed to the project, although other variables may also have influenced the changes. A disadvantage of this method is that the procedures being evaluated are a part of the evaluation process. The evaluations in the Six Mile Creek area were a composite of this approach and that described as the second alternative.

In this study, flood damages for the actual with-project conditions were not appraised. Pre-project rates of damage for shifted land uses were applied to the area of lands flooded under with-project conditions to provide a basis for estimating flood prevention benefits.

Records of land use and crop yields were kept for all flood plain fields in the Six Mile Creek area. Upland land use and yields were represented by sample fields, located one per square mile throughout the watershed. Major indicators used to measure the primary effects of flood protection were changes in land use intensity, yields, and gross value of production, recognizing that other factors, some of them perhaps just as important as watershed protection, may have affected land use and yields.

Other effects of watershed protection were also examined to some extent. Municipal and industrial use of the water stored in the water-detention structures, incidental recreation use of the water in structures, creation of aesthetic values, and changes in community life are prime examples of effects often accruing to watershed protection.

Area and Project Description

Economic geography of Six Mile Creek

The Six Mile Creek Watershed includes 164,627 acres in West-central Arkansas (figure 1). The topography ranges from mountainous in the southern portion to gently sloping valley land in the north. The dominant feature in the south is a series of sandstone ridges trending east-west. Elevations range from 2,883 feet above sea level at Mount Magazine, the highest point in Arkansas, to about 340 feet at the confluence of Six Mile Creek and the Arkansas River.

The channel width of Six Mile Creek at the time of project planning varied from a few feet to about 160 feet, and the channel meandered considerably. The principal tributaries to Six Mile Creek are Hurricane and Short Mountain

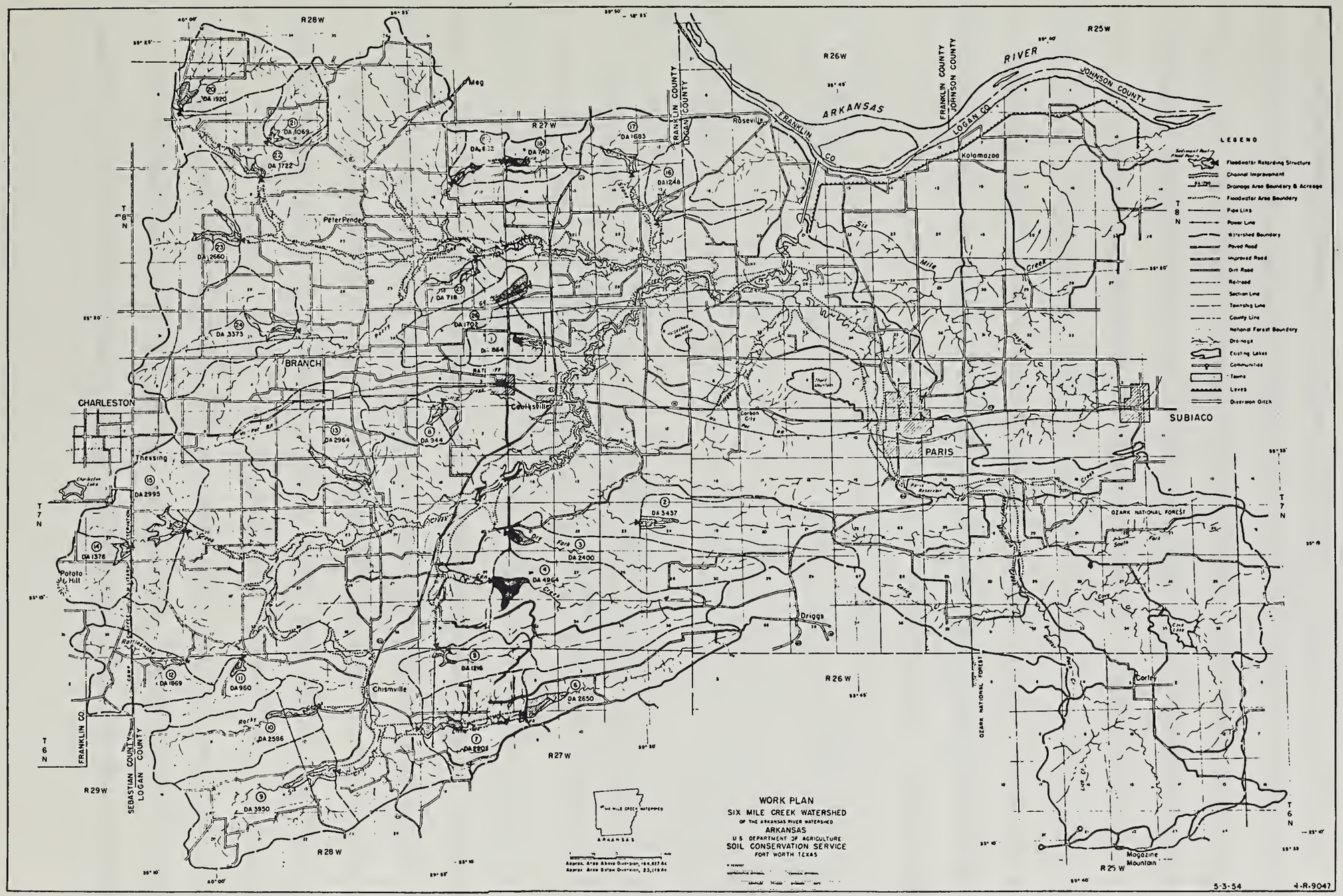

Figure 1. The Six Mile Creek Watershed Project, Franklin and Logan Counties, Arkansas

Creeks. Hurricane Creek is about 16 miles long and drains 40,300 acres in the northwestern part of the watershed. Short Mountain Creek is about 13 miles long and drains 42,527 acres. The municipal water for Paris, Arkansas, is supplied from a reservoir on Short Mountain Creek. There are approximately 14,575 acres of bottomland in the watershed. The flood plain itself is considered to include 12,192 acres.

The Six Mile Creek flood plain was not intensively used for agriculture at the beginning of the evaluation period in 1951. About one-seventh of the land was in crops, as shown below:

Flood plain use	Acres	Percent
Cropland	1,734	14
Idle cropland	184	1
Pastureland	8,020	66
Woodland, miscellaneous and wasteland	1,074	9
Stream channel and reservoirs	1,180	10
Total	12,192	100

The soils were generally in poor physical condition and had fair to poor cover. For the most part, this was a livestock-type farming area. Much of the row-crop farming has been abandoned because of flooding on the more productive soils and for various other reasons, such as the declining comparative advantage of the area for row-crop farming.

The U.S. Forest Service administers some 15,800 acres in the southeastern section of Six Mile Creek Watershed, as part of the Ozark National Forest. Fort Chaffee occupies about 3,140 acres in the western part of the watershed.

At Subiaco, Arkansas, 6 miles east of the watershed boundary, rainfall records have been kept since 1898. The 70-year average rainfall was 45 inches. The 54 rain gages in Six Mile Creek Watershed recorded an average rainfall during the evaluation period of about 42 inches, so the evaluation period can be considered fairly representative with respect to annual rainfall.

Elements of the watershed project plan

Table 1 details the project measures proposed in the Six Mile Creek project, and is duplicated directly from the project workplan as prepared by the Soil Conservation Service. At the time of planning, the total project was estimated to cost about $3.0 million and was anticipated to involve 26 flood-water-retarding structures, 22.9 miles of channel improvement, and 315 acres of tree planting. The total cost of the measures primarily intended for flood prevention (A measures) was estimated at the time of planning to be about $1.4 million.

Recommended land treatment measures (B measures) were directly related to flood prevention, and consisted primarily of establishing or improving sod cover on open fields. Water control structures included terracing, diversion dams, and stream channel improvement. In the workplan the B measures were estimated to involve total installation costs of about $1.5 million.

Table 2 gives actual costs of installing the project as later reported by Soil Conservation Service personnel. These costs total nearly $5.5 million. Twenty-four of the 26 proposed structures, 29.4 miles of stream channel improvement, and 315 acres of critical area plantings were installed. The reported actual installation cost of the structures was about $2.3 million. Reported actual installation costs of $3.5 million for the land treatment

measures was more than double the planning estimate. The number of measures actually installed differed somewhat from those planned. Water-flow control structures were two short of those planned, but establishment of additional grass cover may have compensated in part for this decrease.

It was expected that average annual flooding would be reduced by about 75 percent by the planned structures and land treatment. This reduction of floodwater and sediment damages was estimated to be worth $42,947 on an average annual basis, and more intensive use of land was expected to average $48,883 annually. Average annual conservation benefit from the combined program was estimated at $297,856 after the impoundments were completely installed. Since two of the planned impoundments were not installed, the flood prevention benefits may fall short of estimates. An off-setting factor is the incidental benefits that have accrued to the reservoirs. These benefits were not included in the workplan estimates and are discussed later in the report.

Hydrologic Changes and Effects

Extent of flooding

Stream gage records suggest that annual runoff is more reliable than annual rainfall in establishing a representative evaluation period. Based on the 10-year period 1957-66, annual gaged runoff values of 6.8 inches or less occurred 1-1/2 times more frequently for Six Mile Creek Watershed than for the Petit Jean River gage at Booneville which is for a land resource area similar to Six Mile Creek. But records were available at Booneville for the 27-year period 1940-66, which indicates that the Six Mile Creek evaluation period is not representative of a longer, more normal evaluation period. A similar

difference exists between Six Mile gaging records and those for the gage on Petit Jean River at Danville, for which records exist for a 50-year period (1917-66).

The primary goal of the Six Mile Creek project was to reduce flooding. This reduction was expected to stimulate changes in land use and encourage more intensive land use. Table 3 shows that a significant degree of flood plain protection was achieved. The reduction in the annual acreage flooded after major structures were completed in 1957 ranged from a low of 51 percent in 1961 to a high of 82 percent in 1963. The modest percentages for 1955 and 1956 resulted because installation was just getting well underway.

The cumulative amount of land protected from flooding since the project was begun in 1955 through 1966 was 136,415 acres, or an average of 11,367 acres annually. Excluding 1955 and 1956 (structures were not fully installed), a total of 131,588 acres, or an average of 13,159 annually, were protected from flooding. The acreage protected ranged from 1,419 acres in 1963 (the wettest year) to 25,687 acres in 1957 (the driest year).

Historically, flooding along Six Mile Creek and Hurricane Creek has caused extensive damage. During the period 1923 to 1942 inclusive, there were 31 major floods on the main stem of Six Mile Creek and 78 major floods on Hurricane Creek. A 'major flood' is considered to inundate 50 percent or more of the flood plain. During this same period, there were 90 minor floods on Six Mile Creek and 50 on Hurricane Creek. The total number of floods was 121 (6 per year) on Six Mile Creek and 128 (6.4 per year) on Hurricane Creek. In contrast, during the period from 1957 to 1966, there were 44 floods in the Six Mile Creek Watershed (4.4 per year). Under pre-project conditions, 31 of

the 44 events would have been major floods, and 13 would have been minor floods. The project reduced 26 of the 31 potential major floods to actual minor floods. Of these 39 minor floods, 24 inundated less than 30 percent of the flood plain area and 7 were of little significance.

As was stated earlier, the average rainfall during the evaluation period was about 42 inches, varying less than 3 inches from the 70-year average recorded at Subiaco, Arkansas. Therefore, the reduced number of floods on the watershed can reasonably be attributed to the watershed project, if we can assume that rainfall intensities during the evaluation period were comparable to those occurring in 1923-42.

Flood damage prevention benefits

Table 4 shows that from 1957, when the last structure was completed and in operation to 1966, annual floodwater damages ranged from 62 to 95 percent less than they would have been under pre-project conditions. The largest reduction was in crop and pasture damage, the next largest reduction was in other agricultural damages, and the least reduction occurred in nonagricultural damage. Total benefit during the 1957-66 evaluation period was $341,488, or an annual average of $34,149. Crop and pasture benefits totaled $271,348, or $27,134 annually. Other agricultural benefits totaled $37,400, or $3,740 annually, while nonagricultural benefits totaled $32,740, or $3,274 annually. These benefits would have been greater if the evaluation had covered a longer, more normal period.

Associated streambank erosion

Better control of water was achieved by the Six Mile project; however, it did create one identifiable problem. Increased release rates from flood-control structures, plus the effect of channel straightening, in some instances

contributed to an increased rate of bank erosion. During interviews with farmers on flood plain land, many of them stated that, although the amount and severity of flooding had been reduced, land loss from bank erosion was still occurring and in some locations at a more severe rate. Controlled release of reservoir water keeps the portion of the stream below the reservoir outlet bank-full for several days after a major storm. While release rates result in channel flow generally less than one-half of channel capacity, this causes erosion at the toe of the embankment, with consequent bank caving.

Economic Changes in Land Use and Crop Yields

Evaluation procedures and general effects

Although reduced flooding was the primary planned objective of the Six Mile Creek project, many secondary agricultural effects were also expected. Growing of more high-valued crops in the flood plain and the planting of more upland area to sod crops would serve a dual purpose; soil erosion, with consequent sediment deposition in the stream channel, would thereby be reduced, and net returns from the involved fields could be maintained or increased. Some changes in land use on the flood plain that were anticipated in the project workplan are as follows:

Crop	Without project (acres)	With project (acres)
Cotton	143	314
Corn	161	902
Oats	325	825
Soybeans	24	342
Sorghum for silage	124	418
Grassland and grazed woodland	7,220	8,068

To identify the changes that actually took place, an annual record of land use was kept on each flood plain field throughout the evaluation period, and interviews were held with farmers. All flood plain fields were included, and a sample of fields was chosen to represent the upland. This sample of 7,572 acres formed the basis for showing upland land use and crop yields. To determine the changes in land use brought about by the project, the trends of land use in the watershed--both upland and flood plain--were compared with land use trends throughout Franklin and Logan counties, the two counties in which the Six Mile Creek Watershed is located.

Table 5 shows acreages in major crops on the flood plain over the period 1951 to 1966. The data indicate that the anticipated intensification of land use did not occur on the flood plain. For example, an average of 409 acres of corn during the 4 pre-project years declined to 3 acres in 1966. Cotton was planted on 70 acres in the pre-project period, but diminished to nothing in 1960 and thereafter. The acreage in oats varied considerably throughout the evaluation period, averaging 206 acres before the project and diminishing gradually to 175 acres in 1966. Soybean area was nearly 2-1/2 times as large in 1966 as in the pre-project period, increasing from 133 to 314 acres, with a low of 26 acres in 1955. The acreage in sorghum quadrupled, from 70 acres in 1951-54 to 291 acres in 1966.

There were important changes in the total acreage of cropland on the flood plain during the evaluation period but the relative importance of each crop varied more significantly and the total in 1966 was about the same as in 1951-54. Before the project the dominant crops were corn and oats. In 1966 they were soybeans and sorghum. The total amount of grassland remained fairly

constant, although there were distinct shifts among the acreages in meadow, improved open pasture, unimproved open pasture, and woodland pasture. During 1951-54, improved and unimproved open pasture were about equal in area; there were 3,115 acres of improved open pasture and 2,978 acres of unimproved open pasture. By 1966, this relationship had changed so that there was more than six times as much improved open pasture as unimproved open pasture. The amount of woodland pasture also decreased during the period, but the drop was not as pronounced as was that of unimproved open pasture. This conversion of unimproved open pasture and woodland pasture to improved pasture shows in some measure a more intensive use of land.

Summary of upland and flood plain land use changes

A main objective of the Six Mile Creek Watershed project was to have land used more nearly in line with its capability. Accomplishment of this objective would have been manifested by a shift in intensive cropping from the upland to the flood plain, where the soils are more fertile and where flood hazard would be reduced as a result of the project.

Tables 5 and 6 can be compared in assessing what actually took place. Cropping shifts to the flood plain did not occur to any significant extent. The acreage of corn on both the flood plain and the upland has dropped. Cotton has all but disappeared from the watershed. The acreage of soybeans on both the upland and flood plain has changed considerably. The acreage of sorghum has increased considerably in both areas, although the relative increase in the upland has been greater. Although not shown in table 5, a fairly substantial increase in improved pasture has occurred on the flood plain, within general stability in the total acreage of grassland or woodland grazed.

Watershed versus County land use trends

The total area in crops in the watershed, and in Logan and Franklin Counties as well, trended downward during the evaluation period. The acreage of corn has decreased both in the watershed and in Logan and Franklin Counties. No cotton has been grown in the watershed since about 1960. Cotton acreages in Logan and Franklin Counties decreased considerably between 1954 and 1959, and has since remained constant through 1966, at about one-third the 1954 average. The acreage of oats in the watershed and in the two-county area has decreased in general and at virtually the same rates. But there is no sure trend in the use of land for oats. The acreage of soybeans in the watershed has increased quite rapidly, while the acreage of soybeans in Logan and Franklin Counties has remained about the same. The sorghum acreage in the watershed has increased considerably, but has decreased somewhat in the counties. The amount of meadowland has increased gradually in both the watershed and the two-county area.

These observations on comparative inter-area land use changes suggest that the watershed project had very little effect on land use changes occurring over the project evaluation period. If the watershed project had significantly influenced the pattern of land use, the described trends would likely have been different for the watershed and in the two surrounding counties.

Upland and flood plain productivity changes

Crop yields have been erratic during the evaluation period and were obviously influenced strongly by weather and other factors not related to the project. The number of fields in the watershed devoted to a specific

crop during a given year was small in many cases. The yields estimated for meadow, improved open pasture, unimproved open pasture, and woodland pasture were based on much larger samples than the yields shown for crops.

For illustrative purposes, table 7 shows some inter-area yields for soybeans, as the only major crop whose acreage has shown a persistent increase since 1955.

The productivity of meadow land did not increase significantly during the evaluation period. However, distinct increases in yields did occur for improved open pasture on both the upland and flood plain, as shown in table 8. In the upland area, the productivity of improved open pasture increased from 1.4 animal unit months (AUM) per acre in 1955 to 4.2 AUM per acre in 1966. There have been no significant changes for unimproved open pasture since about 1957 or for woodland pasture.

Concerning the flood plain, the productivity of improved open pasture increased from 1.5 AUM per acre to 4.5 AUM per acre in 1966. On the flood plain the estimated productivity of unimproved open pasture about doubled, going from 1.2 AUM per acre in 1951-54 to 2.4 AUM per acre in 1966. While the productivity of woodland pasture in the flood plain is not shown in table 8 it has increased slightly and toward the end of the evaluation period stabilized at about 0.9 AUM per acre, or at about one-fifth the productivity of improved open pasture. Over-all, the watershed project as such has not influenced crop and pasture productivity too much.

In table 9 are shown yearly estimates (in constant 1959 dollars) of gross agricultural product on the flood plain and upland of the Six Mile Creek Watershed area, emphasizing the evaluation period 1955-66. There has

been a decided increase in the gross real product of agriculture, both in the uplands and on the flood plain. But the increase from upland areas is more pronounced than on the flood plain, which is a reflection of substantial gains in the productivity and increased acreages of improved pasture on the uplands. About 10 percent of the watershed's current production comes from the flood plain and a modest downward trend in the importance of the flood plain to the watershed's agricultural economy seems to be taking place. If the project structural measures had not been installed, this trend would doubtless be much stronger, particularly since about 1960.

Concluding Observations on the Project Area

New uses for reservoirs

Although the reservoirs have taken some land out of crop production, they have provided direct benefits aside from flood control. The sediment pools have provided year-round water storage. They have been used for fishing and other recreational use, municipal and industrial water reserves, stock water supplies, and irrigation. The grassland in the flood pool areas has provided pasture for livestock. The value of grazing from pasture in the flood pool areas of the reservoirs averaged about $6,900 per year. This represents a gain over that obtained before the reservoirs were constructed.

Fishing was practiced on all the reservoirs on private land. Some of the landowners charged user fees for the privilege of fishing; others did not. Some owners charged yearly fees to private clubs for exclusive fishing rights for club members, but in most instances the reservoirs have been open to the public for recreational use. An estimated average annual income of approximately $2,900 has accrued to the owners of land bordering these pools.

According to the Meremec River Basin report of the Missouri Water Resources Board (1966), a well-stocked and well-managed small reservoir can support 50 mandays of fishing per surface acre per year. The total surface area of the sediment pools of the 24 reservoirs in the Six Mile Creek Watershed is 572 acres. At the above rate they could provide 28,625 mandays of fishing per year. Because recreational use is secondary in importance to flood control, however, these reservoirs are not intensively managed for fishing. Fishing and other recreational uses were not planned as specific purposes to be provided by the reservoirs. The reservoir space reserved for storage of sediment will in time lose its capacity for retaining water and, at that time, recreational opportunities will be severely limited.

The city of Booneville pays $800 per year for the use of water from two reservoirs for standby purposes. It pays an additional fee to the reservoir owners for water drawn in excess of a specified amount. Interviews with plant officials indicated that, because of the availability of a supplemental water, Booneville was selected over 9 other towns in Arkansas as the site for a plant employing more than 300 persons. The plant began operation in 1956. Without supplement, Booneville's water supply would have been inadequate during dry periods to sustain the added burden the new plant would impose on the system.

Another reservoir provides water for fire protection, and for a second industrial plant in the watershed. Average employment of the plant is about 150, with a yearly payroll of $600,000. The plant pays the reservoir owners $300 per year for the water. The original plan for the reservoir was modified to increase its capacity for storage, thus making it adequate for this purpose. Several reservoirs provide stock water. At least one has been used as a source of irrigation water.

A few landowners received payment for supplying reservoir water for gas well-drilling operations in the vicinity. However, this was a non-recurring source of income.

These direct cash benefits from use of reservoir water were not included in the plan for the project nor in the computation of expected benefits.

General economic trends and development

As has been pointed out in preceding sections of this report, the Six Mile Creek Watershed is in an area of declining agricultural importance. Cashcrop production on the family-size farms, which are typical of the watershed area, is not competetive with the large commercial farms. As shown in table 10, agricultural employment in the two watershed counties has fallen off sharply since about 1960, and since probably well before then. Data in the Agricultural Census show further that agricultural employment in 1964 was only about 68 percent of what it was in 1954 for Logan and Franklin Counties.

According to the Arkansas Department of Labor, employment in Sebastian County, an urban county immediately west of the watershed, increased 51 percent during the 12-year evaluation period, despite a drop in agricultural employment of approximately 40 percent from 1954 to 1964, as determined from the Census of Agriculture.

These employment trends indicate a movement of farm people into off-farm work, reflecting the area's reduced comparative advantage in agricultural production. Some find this work within their home county, while others commute to adjoining counties.

The rapid development of Ft. Smith in Sebastian County has added impetus to this exodus from the farm. This suggests an important reason why farming activity in the watershed did not adjust as expected, to take advantage of the flood protection brought about by the project. It clearly demonstrates the effect and role of forces exogenous to the watershed area. Credence is also given to the argument that small watershed projects should not be planned in isolation from the economic environment of which they are a part.

About 500 persons are employed by industrial plants that were located in the vicinity of the watershed in 1956 and 1957. As explained in the section on reservoirs, the availability of an adequate water supply was a determining factor in the location of one of these plants.

The combined payroll of the two plants is more than $3.0 million annually. This is obviously a stimulant to the economy of the area. The pilot project was instrumental in bringing the plants to the area, although it was not planned that way nor were any benefits claimed from this source.

The trend in the Six Mile Creek Watershed area away from fulltime farming began before the project was installed. This trend has not been altered to any great extent by the watershed program. In estimating project-induced changes in agriculture, the planners could not consider all the external influences and the changes they might produce. In retrospect, these externalities have been more influential in determining the structure of agriculture in the watershed than has the flood-control program.

In view of these general trends in economic activity, a different mix of project measures may have been more appropriate. The storage space above floodwater retarding structures may have greater value for meeting industrial, municipal and recreational needs. However, the major portion of this space is now preempted for flood control.

List of Tables

Table 1
Estimated Installation Cost - Total Needed Program
SIX MILE CREEK, ARKANSAS
(Arkansas River Watershed)

Measures	Unit	No. of Units to be Applied	Estimated Total Cost			
			Federal	Non-Federal Public	Private	Total
			(dollars)	(dollars)	(dollars)	(dollars)
A-Measures Primarily for Flood Prevention (SCS)						
Floodwater Retarding Structures	Each	26	994,935	12,223 1/	63,804 2/	1,070,962
Stream Channel Improvement						
(a) Channel Capacity Im.	Mile	22.9	300,742	3,000	1,260	305,002
Sub-Total			1,295,677	15,223	65,064	1,375,964
(FS)						
Stabilization of Critical Runoff & Sediment Producing Areas						
(a) Revegetation of Critical Areas						
(1) Tree Planting (Private Land)	Acre	315	5,240	- 3/	4,810	10,050
Sub-Total			5,240	-	4,810	10,050
Total A-Measures			1,300,917	15,223	69,874	1,386,014
B-Measures for Conservation of Watershed Lands that Contribute Directly to Flood Prevention (SCS)						
Cover Cropping	Acre	13,972	-	-	90,815	90,815
Terracing	Mile	52	-	-	9,100	9,100
Diversion Construction	Mile	32	-	-	8,800	8,800
Waterway Development	Acre	161	-	-	10,465	10,465
Land Clearing (New Pasture)	Acre	2,398	-	-	83,930	83,930
Pasture Seeding	Acre	11,450	-	-	320,595	320,595
Pasture Improvement	Acre	29,401	-	-	323,410	323,410
Range Improvement	Acre	47,057	-	-	263,330	263,330
Revegetation	Acre	474	-	-	35,550	35,550
Pond Construction	No.	565	-	-	127,125	127,125
Stockwater Developments	No.	61	-	-	6,100	6,100
Farm & Ranch Planning & Application Assistance	Acre	41,212	67,382	-	-	67,382
Sub-Total			67,382	-	1,279,220	1,346,602

Work Plan, Six Mile Creek Watershed, Soil Conservation Service, U. S. Department of Agriculture, June 1954.

Table 1 - Continued
Estimated Installation Cost - Total Needed Program
SIX MILE CREEK, ARKANSAS
(Arkansas River Watershed)

Measures	Unit	No. of Units to be Applied	Estimated Total Cost			
			Federal	Non-Federal Public	Private	Total
(FS)						
Tree Planting (Private Land)	Acre	2,995	-	-	56,270	56,270
Tree Planting (National Forest)	Acre	425	9,265	-	-	9,265
Fencing for Grazing Control	Mile	70	-	-	18,200	18,200
Cooperative Forest Fire Control	Acre	54,000 4/	5,010	4,590	-	9,600
Roadside Erosion Control (Nat'l Forest Roads)	Mile	20.7	5,185	-	-	5,185
Technical Services, Forest Land	Acre	17,162 5/	20,700	6,500 6/	-	27,200
Sub-Total			40,160	11,090	74,470	125,720
Total B-Measures			107,542	11,090	1,353,690	1,472,322
Facilitating Measures						
Program Evaluation (SCS)			78,680	-	-	78,680
Work Plan Development (SCS)			55,750	-	-	55,750
Work Plan Development (FS)			5,125	-	-	5,125
Total Facilitating Measures			139,555	-	-	139,555
Grand Total			1,548,014	26,313	1,423,564	2,997,891
Total A & B Measures			1,408,459	26,313	1,423,564 7/	2,858,336
Total SCS (W.P.Funds)			1,497,489	-	-	-
Total FS (W.P.Funds)			50,525	-	-	-
Going Program Farm & Ranch Planning and Application Assistance	Acre	65,000	97,500	-	-	97,500

Note: Footnote shown on Table 1 Footnote Sheet

Table 1.--Footnotes

1/ Relocation of roads and power lines.

2/ Value of land easements and rights-of-way and local assistance obtaining same.

3/ May involve nominal State contribution through technical advice and guidance.

4/ Not measurable in acres per year. Fire control needs represent the additional facilities, etc., to provide adequate protection for 54,000 acres (total forest land less national forest acreage) and are essentially the same as needs calculated in terms of protecting the estimated future acreage of forest and forest range (51,096 acres).

5/ Annual application cannot be expressed in physical units. Needs are based on providing management assistance on future private lands to be managed for timber production, estimated at 17,162 acres; and to supply technical services for installation and application of forestry measures.

6/ Estimated contributions by State people roughly equivalent to three man-months (one-third of this in F.Y. 1954).

7/ Includes $54,375 that may be available from other Federal funds (ACPS) to reimburse private interests.

Table 2. Project Installation Cost

SIX MILE CREEK WATERSHED (Pilot) - Arkansas

Installation Cost Item	Unit	Number Applied	Cost (Dollars) Federal	Non-Federal	Total
LAND TREATMENT MEASURES					
Soil Conservation Service					
Cover Cropping	Acre	27,631	-	179,600	179,600
Terracing	Mile	24	-	4,200	4,200
Diversions	Mile	14.1	-	3,880	3,880
Land Clearing (New pasture)	Acre	5,332	-	186,620	186,620
Pasture Seeding	Acre	57,526	-	1,610,730	1,610,730
Pasture Improvement	Acre	47,472	-	522,190	522,190
Range Improvement	Acre	58,100	-	325,360	325,360
Revegetation	Acre	348	-	26,100	26,100
Ponds	No.	708	-	159,300	159,300
Technical Assistance			183,256	-	183,256
SCS Subtotal			183,256	3,017,980	3,201,236
Forest Service					
Tree Planting					
Private Land	Acre	802	-	15,240	15,240
National Forest	Acre	594	12,950	-	12,950
Fencing for grazing control	Mile	22	-	5,720	5,720
Roadside erosion control	Mile	21	5,250	-	5,250
Forest fire control	Acre	54,000	5,010	4,590	9,600
Technical Assistance			3,727	-	3,727
FS Subtotal			26,937	25,550	52,487
TOTAL LAND TREATMENT MEASURES			210,193	3,043,530	3,253,723
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	24	1,204,767	-	1,204,767
Stream Channel Improvement	Mile	29.4	238,090	-	238,090
SCS Subtotal			1,442,857	-	1,442,857
Forest Service					
Critical Area Stabilization	Acre	315	25,832	-	25,832
FS Subtotal			25,832	-	25,832
Total - Construction			1,468,689	-	1,468,689
Installation Services					
Soil Conservation Service					
Engineering Services			435,686	-	434,686
Other			217,843	-	217,843
SCS Subtotal			653,529	-	653,529
Forest Service			13,292	-	13,292
Total - Installation Services			666,821	-	666,821
Other Costs					
Land, Easements and Rights-of-Way			-	97,100	97,100
Total - Other Costs			-	97,100	97,100
TOTAL STRUCTURAL MEASURES			2,135,510	97,100	2,323,610
TOTAL PROJECT			2,345,703	3,140,630	5,486,333
SUMMARY					
Subtotal SCS			2,279,642	3,115,080	5,394,722
Subtotal FS			66,061	25,550	91,611
TOTAL PROJECT			2,345,703	3,140,630	5,486,338

November 1967

Table 3.--Acres protected from flooding in Six Mile Creek, Arkansas, 1955-66

Year	Assuming no project	Measured with project	Reduction due to project	Percent reduction	Total annual rainfall
	Acres	Acres	Acres	Percent	Inches
1/ 1955	17,851	16,015	1,836	10	34
2/ 1956	9,307	6,316	2,991	32	36
3/ 1957	47,242	21,585	25,687	54	65
1958	36,123	16,453	19,670	54	50
1959	21,528	9,519	12,009	56	48
1960	11,953	4,923	7,030	59	42
1961	24,692	12,090	12,602	51	54
1962	8,472	1,847	6,625	78	40
1963	1,724	305	1,419	82	24
1964	23,864	7,836	16,028	67	44
1965	32,161	11,106	21,055	65	38
1966	16,517	7,024	9,493	57	32
1955-66	251,434	115,019	136,415	54	--
1957-66	224,276	92,688	131,588	59	--

1/ 6 structures operating in 1955.

2/ 14 structures operating in 1966.

3/ 24 structures operating in 1967 and thereafter.

Table 4.--Flood protection benefits in Six Mile Creek, Arkansas, 1955-66

Year	Crop and pasture benefits	Other agricultural benefits	Non-agricultural benefits	Total annual benefits	Damages without project	Percent total damage reduction
			-Dollars-			
1/ 1955	1,550	510	760	2,820	13,750	20
2/ 1956	3,185	775	620	4,580	9,765	47
3/ 1957	49,510	6,400	4,835	60,745	67,630	89
1958	65,980	6,770	6,235	78,985	83,410	95
1959	36,100	4,750	6,290	47,140	54,205	87
1960	7,715	2,485	1,800	12,000	19,235	62
1961	23,600	4,030	3,990	31,620	57,745	55
1962	6,735	1,305	560	8,600	9,955	86
1963	1,626	30	0	1,656	1,950	85
1964	28,667	3,710	2,660	35,037	48,537	72
1965	31,514	5,140	3,990	40,644	58,111	70
1966	19,901	2,780	2,380	25,061	35,018	71
1955-66	276,083	38,685	34,120	348,888	459,311	76
Per year	23,005	3,223	2,843	29,072	38,274	76
1957-66	271,348	37,400	32,740	341,488	435,796	78
Per year	27,134	3,740	3,274	34,149	43,580	78

1/ 6 structures operating in 1955.

2/ 14 structures operating in 1956.

3/ 24 structures operating in 1957 and thereafter.

Table 5.--Major flood plain crops in Six Mile Creek, Arkansas, 1955-66, with data for 1951-54 and for grazing land use

(Total flood plain area is 12,192 acres)

Year	Corn	Oats	Soybeans	Sorghum	All crops 1/	Grassland and woods grazed 2/
			Acres			
1951-54	409	206	133	70	1,071	9,320
1955	281	409	26	169	1,157	9,681
1956	220	552	53	368	1,639	8,657
1957	42	138	51	246	588	8,945
1958	48	282	115	304	869	8,891
1959	125	154	245	234	839	8,528
1960	175	98	175	144	618	9,328
1961	85	129	266	95	613	9,537
1962	99	65	332	52	624	9,692
1963	140	49	195	122	621	9,857
1964	60	83	248	275	732	9,929
1965	82	107	220	313	875	9,246
1966	3	175	314	291	1,027	9,588

1/ Includes other crops not tabulated, such as cotton, wheat, miscellaneous, soil bank, etc. Cotton acreage declined from an average of 70 acres for 1951-54 to zero in 1960 and thereafter.

2/ Includes meadow, improved open pasture, unimproved open pasture, woodland pasture, and open pasture in the soil bank program.

Table 6.--Major upland crops in Six Mile Creek, Arkansas, 1955-66, with data for 1951-54 and for grazing land use

(Total upland area is 121,450 acres)

Year	Corn	Oats	Soybeans	Sorghum	All crops 1/	Grassland and woods grazed 2/
			Acres			
1951-54	408	1,573	288	119	2,299	117,432
1955	45	1,997	--	278	2,741	89,056
1956	270	1,620	--	1,459	2,288	97,007
1957	17	1,146	--	885	4,087	84,064
1958	173	538	--	503	3,625	79,175
1959	69	1,544	86	347	3,342	87,423
1960	56	645	295	862	4,278	100,173
1961	112	494	--	684	3,147	99,598
1962	--	299	56	900	2,896	97,487
1963	17	45	1,009	1,210	5,010	97,431
1964	17	67	659	905	5,173	101,409
1965	0	328	422	2,101	2,437	103,848
1966	0	1,207	409	81	3,750	103,840

1/ Includes other crops not tabulated such as cotton, wheat, miscellaneous, soil bank, etc. Cotton acreage went from an average of 120 in 1951-54 to 364 acres in 1956, and then to nothing in 1957 and thereafter.

2/ Includes meadow, improved open pasture, unimproved open pasture, woodland pasture, and open pasture in the soil bank.

Table 7.--Inter-area soybean yields in Six Mile Creek, Arkansas, 1955-66 with average for 1951-54 and surrounding County data

Year	Watershed upland	Watershed floodplain	Watershed average	2-County average 1/
	Bushels grain per acre			
1951-54	11	10	11	23
1955	na	15	15	na
1956	na	30	30	na
1957	na	15	15	na
1958	na	26	26	na
1959	26	13	16	19
1960	15	16	16	na
1961	na	24	24	na
1962	20	18	18	na
1963	16	14	16	na
1964	12	19	14	21
1965	20	16	19	na
1966	20	19	20	na

1/ Data are arithmetic means of weighted means for Franklin and Logan Counties, as estimated from Censuses of Agriculture.

Table 8.--Inter-area pasture productivity in Six Mile Creek, Arkansas, 1955-66, with average for 1951-54 and excluding woodland grazed

Year	Unimproved pasture		Improved pasture	
	Watershed upland	Watershed floodplain	Watershed upland	Watershed floodplain
	Animal unit-months per acre			
1951-54	0.9	1.2	1.4	1.5
1955	1.0	1.3	1.6	1.9
1956	1.0	1.3	1.6	1.9
1957	2.2	2.9	3.1	3.8
1958	2.3	2.8	3.3	5.0
1959	2.2	3.9	3.6	4.1
1960	2.2	3.0	3.7	4.1
1961	2.4	2.2	5.1	5.1
1962	2.3	2.6	4.2	4.6
1963	2.1	2.3	3.8	4.1
1964	2.3	2.3	3.6	4.1
1965	2.3	2.5	4.0	4.8
1966	2.2	2.4	4.2	4.5

Table 9.--Gross agricultural product in Six Mile Creek, Arkansas, 1955-66, with average for 1951-54 and upland/floodplain comparison

Year	Watershed upland	Watershed floodplain	Watershed total	Percent from floodplain
	Thousands of dollars			Percent
1951-54	520	80	600	13.3
1955	455	79	534	14.8
1956	548	80	628	12.7
1957	737	102	839	12.2
1958	630	119	749	15.9
1959	555	108	663	16.3
1960	813	108	921	11.7
1961	849	130	979	13.3
1962	971	122	1,093	11.1
1963	821	110	931	11.8
1964	1,387	130	1,517	8.6
1965	1,037	136	1,173	11.6
1966	1,037	127	1,164	10.0

Table 10.--Agricultural and nonagricultural employment in Franklin and Logan Counties, Arkansas, 1955-66 1/

Year	Agricultural employment		Nonagricultural employment		Total number reported
	Number	Percent	2/ Number	Percent	
1955	na	--	1,519	--	na
1956	na	--	1,910	--	na
1957	na	--	1,750	--	na
1958	na	--	1,654	--	na
1959	na	--	1,918	--	na
1960	1,350	40	1,939	60	3,289
1961	1,275	38	2,118	62	3,393
1962	1,225	36	2,247	64	3,472
1963	1,175	33	2,388	67	3,563
1964	1,025	28	2,579	72	3,604
1965	950	27	2,516	73	3,466
1966	825	21	3,074	79	3,899

1/ Source: Employment Security Division, Arkansas Department of Labor.

2/ Excludes the following workers: domestic, self-employed, unpaid family, interstate railroad, government, employees of non-profit institutions.